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ADDRESS OF THE PRESIDENT:

THE MICROSCOPE IN THE INVESTIGATION OF BURNS AND SCORCHES ON TEXTILE FABRICS.

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Mr. Chairman, Ladies and Gentlemen: The subject which I have chosen for my address is one that has partly a popular and partly a scientific interest, as is meet in a mixed audience like that which usually assembles to listen to the annual addresses of our presidents. The experiences therein related belong to the domain of legal *expertise*, and are in a line not hitherto exploited, so far as I am aware. In my investigations I was necessarily compelled to stray into paths in which the microscope did not directly play an important part, but in which it indirectly and finally proved to be the agent of saving a human life, and establishing the innocence of one unjustly accused of one of the most heinous crimes known to man—the cold-blooded and cruel murder of a young wife about to become a mother. The steps by which this result was obtained justify the title of my discourse. To make these plain, a narration of the events leading up to the investigation will be necessary.

It was in the early spring of 1890, when Charles F. Vail, a young business man of St. Louis, and his wife, a young and beautiful

woman, to whom he had been married less than a year, left the house of a relative, with whom they had been spending a few days, to take the railroad for home. The country house was some distance from the station, and a spring wagon had been brought to the gate to convey them and some members of the family thither. The wagon was turned so that the "hound" projected sufficiently to make a stepping point, and Mrs. Vail started to climb to the seat. Her husband, standing behind her, assisted her to rise, but just as she was about to step from the hound up to the seat she lost her balance, turned, and fell backward, throwing her husband, who was of slight build (while she was large and solidly built), against the hind wheel. A muffled report was heard, and Mrs. Vail fell into the arms of her husband, shot through the body. She was carried into the house of her relative, where in the course of a few hours she died. On examination it was found that a Smith & Wesson pistol, thirty-two caliber, old style, had exploded in Vail's overcoat pocket, as he claimed, by striking against the rim of the wheel.

The matter was regarded as an accident at the time by all the eyewitnesses, and Mrs. Vail died protesting that it was such. In a few days, however, ugly rumors were set afloat. It was discovered that Vail carried accident and other insurance upon his wife to the amount of upwards of $20,000. It was also discovered that there had been a romance connected with the marriage of the couple, and that they had been married for several months before Vail would consent that the fact should be published. These and other rumors caused the insurance companies to refuse to pay the policies.

Without going any further into the minutiæ of the preliminaries, there was an autopsy held upon the deceased, the coroner's verdict implicated Vail, and he was thrown into jail. At the preliminary examination he was remanded for trial without bail, and subsequently indicted for murder.

As usual in such cases, the daily newspapers made the most of the sensation. Both Vail and his wife were well known in the city, and were well, even highly, connected. Upon the face of the evidence adduced at the preliminary examination, as manipulated by the reporters, Vail was presented to the public as a fiend incarnate. He was tried, condemned, and executed by the newspapers, all of which in the city vied with each other in concocting or unearthing some piece of circumstantial evidence that went to prove that Vail had carefully planned the murder months beforehand. The insurance companies employed the best legal talent in the city to aid the pub-

lic prosecutor, and, as usual in cases where large sums are at stake, detectives, as well as other men ready to perjure themselves for a fee, were not wanting. So numerous and apparently well-authenticated were the published reports of former attempts of Vail to murder his young wife that there was scarcely a man, woman, or child in the community that did not look on the prisoner as the most diabolical of villains. Even I was so firmly convinced of his guilt that I told his attorney when he called upon me for my services as expert, that I believed his client a monster for whom hanging was too good. Even the eye-witnesses, who at first declared the shooting accidental, had turned against the unfortunate and now denounced him as a murderer.

Only his mother and sister, father and brother, and his faithful friend and attorney, Mr. Marshall McDonald, believed in his innocence. Every other human hand was against him; every other human being clamored for his blood.

Vail repeatedly told in interviews and otherwise, his version of how the tragedy occurred. His pistol, said he, was lying on the bureau in the room which he and his wife had occupied. His overcoat pocket had been ripped in some manner, and his wife had just finished mending it when the wagon for the station was announced. He hastily put the garment on, and picking up the pistol dropped it loosely in the right-hand outside pocket, hammer down and handle upward, intending to change it after they were under way. Unfortunately for him and his wife, however, he did not have the opportunity of doing so. "It struck against the wheel," said he, "and went off; how, I hardly knew myself. It was very muddy at the time, and the wheels were full of the peculiar clayey soil of the place. If I could get my overcoat, it would surely show what I say to be true."

Unfortunately for the prisoner the overcoat had been taken from his possession at the preliminary examination, and was held by the prosecution, who resolutely refused to allow the defense even to see it, much less to have it in their possession.

As the time for the trial drew near the attorneys for the defense saw clearly how vital for their cause became the possession of that coat. No one but the prosecuting attorney knew where it was, and he would not tell. Finally Mr. McDonald, the leading counsel for the defense, learned that it was locked up in a certain place in the property-room of the criminal court, and after he had exhausted all legal forms of getting hold of it, he determined on a desperate course,

to wit, to break into the property-room and take the coat. It might be burglary and he might be disbarred and sent to the penitentiary for it, but his client's life hung in the balance; and, believing that the end justified the means, he successfully carried out his plan.

The disappearance of the garment from its accustomed place was soon discovered, and the newspapers again pretended to see in it the sinister hand of the assassin making way with proofs of his guilt.

Within a few hours after its capture it was delivered to me for a minute and critical study. It had evidently been worn and handled a great deal since it passed out of its owner's hands. It had even been carefully brushed (as was afterward proven at the trial, a party having testified to having worn it while on a ride several miles across country and having cleaned the mud off before starting and after coming back).

The problems presented to me were:

1. To discover, if possible, the remains of the clay that was rubbed off the wheel by the coat.

2. The relative position of the pistol in the pocket—that is, whether it was resting hammer upward or hammer downward.

3. The relative position of the pocket toward the balance of the garment, or, in other words, whether the pocket was hanging naturally or whether it was thrust upward by the hand and brought near the point of exit of the ball when the shot was fired.

4. As a corollary to the foregoing, whether the muzzle of the pistol was jammed into the corner of the pocket, as would be contended by the prosecution, or whether it was a little way from the corner.

5. Whether the muzzle of the pistol was in close proximity to the lining and body of the garment at the moment of explosion, or at some distance from it.

The first question was easily settled with a loupe, amplifying about two or three diameters. Under the nap of the garment, away from the effects of brushing, remains of the band of clay were found; but how to settle the balance was another matter.

The coat itself was of chinchilla, cotton warp and heavy wool weft. The lining was of silk and cotton stuff, faced with satin. The pocket was of heavy twilled wool and cotton goods. There was some cotton batting, and finally some heavy linen stiffening, "buckram," I believe the tailors call it, and the ball in its flight, and a portion of the flame had passed along all of these, which embrace, as stated, cotton, linen, silk, and woolen fibers, or nearly all of those

used in textile fabrics. Both the ball and the flame must have left a record of their path. That of the former was comparatively easy to trace. It had torn a characteristic triangular hole in the corner of the pocket and had emerged from the chinchilla just where the satin facing was sewed to it, making a clean round hole not much larger than a small lead-pencil, or say a quarter of an inch in diameter.

You will understand that in such examinations the expert is not allowed to mutilate the garment in any manner except by order of the court or by the consent of all parties in interest. Under the circumstances we could get neither of these, and hence the examination was rendered far more difficult than it would otherwise have been.

On turning the pocket "inside outward" I found on either side of the same, near the bottom, a faint stain, which, so far as inspection with the naked eye went, might have been caused by iron-rust, by liquids, or by a scorch. Constant handling and rubbing of the walls together had worn off all charred material. With the tube of the microscope removed from the stand, and armed with a two-inch eye-piece and a two-inch objective, examining the surface by direct light, I could discover little or no evidences of powder-burn as usually seen. With the aid of the glass, however, I was able to trace out the exact limits of the stain and its shape, which was that of a figure 8, or rather of two circles, each about seven-eighths of an inch in diameter, overlapping each other at one point about one-quarter of an inch from their peripheries. The centers of these circles seemed somewhat more deeply eroded than the balance, but even in these there were no tell-tale ends of burned fibers.

If these are burns or scorches, I asked myself, how came they in this position in the pocket and how were they caused? An examination of the pistol, or rather of an exact duplicate of it, at once gave the clue. If you will examine any of the repeating fire-arms of the Colt, Remington, or Smith & Wesson patterns, you will note that between the muzzle of the revolving cylinder and the barrel there is a small space, say the fiftieth of an inch, left intentionally by the makers to allow for expansion of the parts under heat and to insure free revolution of the cylinder. In firing the weapon, no matter how narrow the space, some of the inflamed gases must here make their escape, and will leave their record on any substance in close proximity to the weapon.

What sort of a record must this flame leave? A little reflection will show that this will depend largely upon the breadth of the space

through which the jet of inflamed gas makes its escape, upon the "quickness" of the powder, upon the nature of the substance burned, and upon the pattern of weapon used; but, in all events, it will be a very superficial one—a mere scorch. There will be no actual burn such as we find on surfaces "powder-burned" from the close proximity of the muzzle of a discharging weapon, simply because no unconsumed or partially consumed and red-hot powder can escape through the aperture.

What should be the shape and size of this scorch? This I determined partly by geometrical methods and partly by experiment. Assuming from known facts in physics that the escaping gas would not shoot outward as a narrow belt of flame of the thickness of the aperture, but that immediately on issuing from this aperture it would spread and assume a pyramidal form, the base of which constantly widens up to a certain point (which depends, of course, upon the intensity of the jet), but that its greatest energy would remain in a line—in this case a circular plane, passing at right angles through the axis of the weapon—if there were nothing in the way, nothing to break the force of the jet, it is plain that if a surface, a sheet of paper, for instance, be placed parallel to the axis of the weapon, folded around and touching the cylinder, we should have, upon discharging the weapon, a mark on the paper somewhat similar to an hour-glass, intense at the point nearest the source of the flame and gradually weakening and fading the further off therefrom. In actual practice, however, there are three sources of modification of the shape of the scorch—the first, in the broad cap and bottom pieces which unite the barrel and the stock and between which the cylinder revolves; the next, in the pivot on which the latter revolves; and, finally, the shape of the cylinder itself. For practical purposes the latter can be ignored, but the two first named put an exact limit to the area of scorch, obstructing as they do and cutting off the path of the flame, and giving us two oval scorches touching or overlapping each other and forming a more or less accurate figure of 8. Experiments made with 100 pockets similar to the one in the coat confirmed these speculations with the utmost nicety. This fact once established, we are enabled to locate with great exactness the position of the weapon. A line drawn through the longer axis of the figure 8 above noted will give the position of the weapon when it was discharged.

Taking a pocket that had been made by the tailor who made the coat, and of exactly the same stuff that was used in the original

pocket, after scorching it by discharging the pistol, placed hammer downward (by striking the hammer with a tack-hammer through the cloth), I carefully unraveled some of the threads from the scorched portion, after first taking the precaution to rub the surfaces together long and vigorously, and beating to remove all traces of char. I examined the fibers in glycerine, first with a half-inch objective and a two-inch eye-piece, and afterward with a one-fifth-inch objective, to determine what structural changes had been wrought in the wool fibers of which the filament was composed. The first, the half inch, instantly showed that on the side exposed to heat the wool fiber had become opaque, and in places considerably thickened, warped, and twisted. The area and depth of the opacity were in direct ratio to the amount of heat applied. The one-fifth-inch objective showed the same general features, and in addition demonstrated that the opacity was due to a sort of stratification or splitting up of the cortical portion and a granulation of the medullary structure of the wool. The color of originally white (bleached) fibers was changed by the scorch to a reddish brown by transmitted light, which was quite brown by direct light. At points where the char was deep the color was dark brown and even black throughout. Such fibers were greatly thickened, and broke easily. At points where fibers were charred through, the ends were split, the outer envelop curling or being retracted backward and the central portion reduced to a granular mass.

Cotton fibers examined in the same manner showed discoloration at the point of contact with the flames, merging from coal black through various gradations of brown. They were twisted and broken, and where burned through the ends were black, square, or even slightly concave. Much charcoal, in a minutely divided condition, was found among them. This was due to the preliminary rubbing to remove the completely carbonized portion. Occasionally, especially in charred cotton batting, a whole fiber would be found completely carbonized, but retaining the characteristic shape.

After I had settled these points, I carefully withdrew from the stained portion of the pocket of the overcoat, so as to leave no mark of mutilation, a few pieces of the thread and examined them exactly as I had done the foregoing, and found identically the same appearances.

I was now in a position to swear most positively that the discolored surface was a scorch made by the escaping inflamed gases from the space between the cylinder and the barrel of the pistol.

Placing the pistol in another and exactly similar pocket, hammer downward, and discharging it with a tap from a tack-hammer as before, I carefully noted the position of the axis of the scorch and found it to coincide within a quarter of an inch with that in the pocket. Placing the pistol in the pocket, hammer upward, firing as before and marking the position of the space, I found that the latter was some two inches higher than the center of the other burned area, and that its axis was inclined at a different angle from that of the said area. Experiment, by firing the pistol in a pocket exactly similar in size and shape, confirmed this point, and I was enabled further to swear most positively that the pistol was lying hammer down in the overcoat pocket at the time of its discharge.

The next point to settle was whether the pistol was fired by hand. This was easily demonstrated to have been impossible by experiment with the weapon in similar pockets, and I need not dwell upon the matter here.

How far, in all probability, was the muzzle of the pistol from the point of exit of the ball, was the next vital question. This was also solved experimentally, but before the experiments could be accepted as evidence the microscope had again to be resorted to. The silk lining of the coat had not been attached to the hem of the garment, and hence it was a comparatively easy matter to turn the latter wrong side out. On the one side was the silk and cotton stuff used for coat lining, on the under side of which cotton predominated. A strip of buckram extended some six inches from the margin of the coat inward and protected the satin trimming from the action of the flame. The buckram, from its closely twisted nature, showed but a slight discoloration, which might or might not be due to flame. The lining also showed but slight traces of discoloration. Coming to the chinchilla, however, there was an area of about six inches in diameter that, while showing no char to the unaided eye, had evidently been subjected to some denuding influence.

Placing the surface as flat as possible and in a strong direct light, I first went over it with a Coddington lens, but beyond the fact that there were points where the threads were cut and broken by the impact of some substance, I arrived at no direct and positive evidence which would enable me to swear positively that the denudation of this area was due to flame. The round bullet hole in the center and the character of the other marks rendered this conclusion very probable, it is true, but absolute certainty was what I wished to obtain.

Again, before resorting to the expedient of secret mutilation of

the garment, though never so slightly, I resorted to experiment. Taking a piece of chinchilla exactly similar to that used in the overcoat, probably a remnant of the same bolt, as it was procured from the tailor who made the garment, I hung it up in such a manner that it would offer the same resistance to the passage of a bullet as the stuff in the garment. I then put the pistol in a pocket exactly similar to that in the coat, and discharged it by a slight blow upon the hammer (which rested, of course, upon the cartridge, which latter was one exactly similar to that in the pistol at the time of the accident). The muzzle was about six inches from the chinchilla. The discharge made the characteristic marks in the pocket, the characteristic tear in woolen and cotton twill material, bored a ragged hole about three-quarters of an inch in diameter through the chinchilla, and made a burn about four inches in diameter. Taking the chinchilla and rubbing it until pretty much all the char had been removed, I passed it backward and forward over a stage prepared for the purpose and over which I had mounted the tube of my stand, armed with a two-inch eye-piece and a two-inch objective. The "stage" was simply a wedge-shaped block of wood eight inches long, three inches high, and four inches wide at the bottom. The width narrowed toward the top to one inch and was then smoothly rounded off. The bottom was grooved lengthwise with an ordinary grooving plane. This block sat on a plane board eight inches wide and sixteen inches long, to which was bradded, down the center, a tongue which fitted into the groove on the bottom of the block. The "stand" consisted of a percolator supporter, with an arm bearing a wooden clamp which held the tube-carrier sufficiently firmly for my purpose. Adjustment was made, as in the old Nachet stands, by sliding the tube carrying the lenses up or down with a slight rotary motion. Finer adjustment was obtained by touching the arm with the finger.

On examining the surface of the stuff by a strong direct light I had no difficulty in finding pits in the material, in which, in many instances, I found unburned or partially burned grains of powder. The ends of the thread plainly showed charring and presented the same general appearances when withdrawn and examined separately as those already described in the cases of wool and cotton. The bit of chinchilla now gave place to the coat itself, and with considerable difficulty I went over the whole denuded surface around the bullet hole, hunting for grains of imbedded powder. Cavities where they *had* been were plenty, but the grains themselves had long since

been rubbed or shaken out. Finally, however, my search was rewarded by finding two cavities close together, each of which contained a grain of powder. With a pair of delicate forceps I removed a couple of the cut threads between these two cavities and examined them separately after teazing them out to get at the fiber. They were cotton and very strongly charred.

I was now in a position to swear positively that the whole of this denuded area was due to char or scorch or burn from the discharge of a fire-arm. I say the *whole of the area*, and emphasize it, because thereon hangs one of the most important points of the defense.

In any series of experiments where the same weapon and the same charge are used each time, the area of the scorch is in direct ratio to the distance of the muzzle of the weapon from the surface scorched. This may be accepted as an axiom; and, as a corollary, we may add that the depth of the scorch and penetration of the powder will be in inverse ratio to the said distance.

These facts furnish us with an accurate scale by means of which, having a similar weapon and a similar cartridge, we may determine, within a margin of an inch, the exact distance from any powder-burned surface at which a shot was delivered.

In the present instance experiment proved that the muzzle of the weapon was not more than eleven nor less than nine inches from the point of exit. This was corroborated in a singular manner by the character of the hole made by the ball as it left the overcoat. It was, as I have stated, a smooth round hole, about one-quarter of an inch in diameter. By actual experiment, many times repeated, we subsequently proved that eight inches from the muzzle of the pistol, under the circumstances, being fired each time through a heavy twilled pocket, was the nearest distance at which the kind of cartridge used could possibly make a smooth round hole. The hole becomes more jagged and larger the nearer the muzzle approaches the cloth, until when in actual contact (as it was claimed by the prosecution *was* the case in the shooting of Mrs. Vail) a great hole, from two to three inches in diameter, is blown bodily through the stuff, leaving the latter torn in every direction and almost always on fire.

These points being settled, I next examined the buckram or heavy linen stiffening. The fibers of this material give the least evidence of change under the scorching influence of the gas. There were no powder marks or cavities, and the most that I could discover was a slight deposit of soot on the outer side of the thread. In buckram scorched by experimental discharge, the threads unraveled and picked to

pieces showed no structural changes. The burned ends of fibers are always conical and opaque for a short distance back from the burned portion. From its exceedingly hard and closely twisted nature, this is what we might expect.

A piece of fine linen cambric, unstarched, scorched by the side flash from the aperture between the muzzle of cylinder and the barrel of the pistol, was far more strongly marked. There were no detectible structural changes, but the fibers were deeply burned on the exposed side, sometimes down to more than half their diameter, and in a few instances burned through.

A piece of the same cambric, starched and smoothly ironed, under similar circumstances was not nearly so severely marked.

It is, however, when we come to silk that we find the greatest and most interesting structural changes produced by scorches. When held close to the source of heat (the flame jet) the fibers twist and warp in every direction, at points apparently fusing together and making a network that can be compared to nothing more aptly than to the figure produced by cutting little lines of slits in paper, each line of slits breaking joints with its neighbor, and then opening the paper out, after the fashion of the "expanded metal" screens of the present day. At points burned by partially combusted powder or other glowing matter the whole mass of fibers, constituting a thread end, actually fuse together, making a solid mass, from brown to black in color, and often containing small bubbles of gas. The fibers swell and become opaque, sometimes granulated.

To sum up:

Wool fiber becomes opaque on the side exposed to the flash, thickens in diameter, warps, and frequently twists on itself. The depth of the opacity is in direct ratio to the amount of heat applied. The opacity is found on examination with higher powers to be due to a splitting up of the cortical and a granulation of the medullary structure. In black-dyed fibers the thickening and distortion are the same as in white fibers, but the degree of opacity cannot be observed.

Cotton Fibers.—These are more easily affected by a flame jet than any others examined by me. They show a discoloration at the point of contact with flame, merging from jet black (carbon) to a faint brown, through all graduations of brown. When burned through and subjected to rubbing or manipulations, the end is left either square or slightly concave. Investigations, not mentioned in the foregoing, show that cotton that has not been manufactured, crude

yarn still retaining the oil, warps and twists under heat and displays more tendency to increase in volume than manufactured cotton free from oil.

Linen and Flax.—There appear to be no marked structural changes in these fibers. The ends of a fiber burned in two and cleaned by rubbing are conical in shape and opaque for a short distance back. When not cleaned the end is rounded and has a more or less enlarged head of carbon attached. Occasionally the fibers split at the end.

Silk Fiber.—The fiber twists and warps under the effect of heat. If the latter be great, it seems to melt, and several fibers will fuse together. A brown discoloration is produced by contact with flame in all cases, and this becomes black where the flame is intense. At the ends of fibers exposed (as in silk velvet) to an instantaneous jet of flame, sometimes a small round or roundish knob is formed. In all fabrics, of whatever fiber made, the looser the weaving the more deeply the material is affected by an instantaneous flame jet. The smoother and closer the surface the less the effect and the more difficult the task of detecting old scorches where the surfaces have been rubbed.

These, gentlemen and ladies, are an outline of my work and a summary of results. Commencing with a deep conviction of the guilt of the accused, my investigations led me first to doubt the correctness of this conviction, and afterward convinced me of his innocence. They enabled me to go into the court-room and to prove to the satisfaction of eleven men out of a jury of twelve that the prisoner at the bar, instead of an execrable villain, was the miserable victim of circumstances.

It was my intention to place these results graphically before you in the shape of photographs or colored drawings, but for many months past I have been forbidden the use of my eyes for any such work. Indeed, since New Year's day, up to within a fortnight, the use of the microscope itself has been interdicted. An attack of grippe, from the effects of which I have not yet fully recovered, left my eyes so seriously affected that any attempt to use them for more than two or three minutes at a time was always followed by severe and lasting pain.

With warm weather great amelioration has come, and I will soon be enabled to prepare the drawings for the next volume of proceedings.*

*Dr. James was unable to make the drawings referred to.—W. H. S.